

Money in monetary policy

Information variable? Channel of monetary transmission? What is its role in Poland?

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Design:

Oliwka s.c.

Layout and print:

NBP Printshop

Published by:

National Bank of Poland Education and Publishing Department 00-919 Warszawa, 11/21 Świętokrzyska Street phone: +48 22 653 23 35, fax +48 22 653 13 21

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Abstract

The paper provides an overview of the literature on the role of monetary aggregates for conducting monetary policy and attempts to assess the role of these aggregates in the Polish monetary policy. We compare theoretical and empirical arguments which justify or undermine the need for usage of monetary aggregates by central banks, as well as arguments indicating related problems. We describe the most important areas of the discussion on the role of money in monetary policy. We present studies on the information content of money and the use of that information in the Polish central bank's monetary policy between 1998 and 2011.

Introduction

Opinion that inflation is a monetary phenomenon is one of the central theses of monetary economics. The theory behind this thesis – i.e. the quantity theory of money – states that periods of sustained growth or decline in inflation are accompanied by a faster or slower growth of monetary aggregates, adjusted for long-term trends of output and money velocity. On the other hand, the new Keynesian economics (new neoclassical synthesis), which dominates economic theory for about 20 years, largely disregards money in macroeconomic models and in recommendations for the monetary policy. This is also reflected in the practice of modern central banking.

The current financial crisis has caused a return to discussions on the role of money in monetary policy. It is worth emphasizing that, contrary to the debate during the monetarist revolution, the present one concerns not only monetary aggregates, classified according to the degree of liquidity of their components on the liability side as M1, M2 or M3, but is also, if not primarily, focused on the asset side. In particular, it emphasizes the role of credit, and even liquidity in general because of the confidence crisis after the collapse of Lehman Brothers in 2008 and the application of nonstandard monetary policy measures by some central banks, e.g. purchase of public and private sector assets (the so-called quantitative easing).

It is theoretically justified to concentrate on credit aggregates and not on monetary aggregates. The definition of money in categories of M1, M2 and M3 aggregates causes a number of problems. Firstly, money in the theoretical sense, in accordance with quantity theory of money, is directly connected with nominal income and production, therefore a statistical measure of this category should refer not to the volume of (specified) deposits, but to their part, which translates into demand in real terms. Secondly, the definition of money in categories of private sector assets leads to classification problems, such as which assets should be taken into account and which should not. It is directly connected with the first claim, which indicates that deposits are only the potential (and not effective) measure of expenditures (Werner 1997).

There are opinions that abandoning monetary or credit aggregates in monetary policy caused excessive simplification of the perceived functioning of the monetary transmission mechanism, and neglecting information important for monetary policymakers. Money in the new Keynesian models was entirely endogenous, determined by the interest rate. Essentially in monetary policy models there was one interest rate, which was assumed to be fully controlled by a central bank with short term open market operations. Those assumptions were introduced in spite of the results of empirical studies on the monetary transmission – in particular on the credit channel and interest rate pass through – showing, on one hand, that the supply of loans is influenced by the banks' balance sheets and the level of risk in a banking sector and, on the other hand, that the adjustments of interest rates occur with delay, they are often not full and, simultaneously, their magnitude might be significantly different across certain assets (and liabilities). It means that different types of credits (and deposits) are not perfect substitutes.

The return of monetary aggregates as monetary policy intermediate targets is currently not under discussion. As it is described later, in the case of only a few central banks such strategy turned out to be successful. However, it is postulated to introduce money in the Phillips curve and/or to introduce credit (credit interest rates) in the IS curve, thus to consider money in the models of monetary transmission and the analyses and conduct of monetary policy. It is also recommended to use information included in monetary aggregates in monetary policy rules. The third area of discussion concerns the use of monetary (and credit) aggregates when inferring about asset prices and identifying speculative bubbles in asset markets, thus introducing macro prudential elements in monetary policy. Friedman (1988) pointed on the usefulness of money in the analysis of asset price channel, by underlining the relationship between asset prices in capital markets and money demand. Later on Meltzer (1995) showed that an increase in liquidity leads to the increase in demand for financial assets and augments their prices. Since the beginning of the past decade liquidity and its influence on financial and nonfinancial asset prices is more often discussed in the literature. The rapid increase of house prices in the US and many countries in the EU was undoubtedly a stimulus for development of research on their relationships with credit.

In this paper – which concerns the second area of the discussion – we analyse the usefulness of monetary aggregates in the Polish monetary policy. It complements our previous study, in which we have included loan market and feedbacks between real and financial sectors (Demchuk et al. 2012).

In the first part of our paper we briefly describe conditions of including money or credit in the new Keynesian models and experience of central banks which have based their monetary policy on the monetary aggregates. The second part is an overview of the empirical literature, in which money (or credit) plays a role of an additional source of information or is perceived as a key element in the monetary transmission. The next part discusses the results for Poland: we analyse stability of the money demand function, which is a prerequisite for an effective use of monetary aggregates, and next applying a small structural model we analyse to what extent money should be used in the reaction function of the central bank to meet the criteria of optimality (minimize fluctuations in the real economy and deviations of inflation from the inflation target). The last part concludes.

1. Theoretical considerations and practical experiences of central banks

Microeconomic foundations to justify the presence of money in macroeconomic models are provided by the inclusion of money in the utility function (e.g. Sidrauski 1967). If consumption and money were inseparable in the utility function of households, real money must be present in the IS curve of the model derived on the basis of intertemporal optimisation of behaviour of market participants. However, empirical studies suggest rather that consumption and money are separable in the utility function (e.g. a study for the United States: Ireland 2004, study for the euro area: Andreas et al. 2001) and at most they document some deviations from full separability, for instance in the periods of higher inflation (study for the euro area: Jones and Stracca 2006). Woodford (2003) shows that even if the assumption of separability of consumption and money in the utility function was relaxed, the effects of omission of real money in the IS curve would be negligible.¹

A standard model of monetary policy in the new Keynesian school (cf. e.g. Clarida, Galì and Gertler 1999, Woodford 2003) is built around three equations explaining the output gap, inflation and the (short term) interest rate.² Money is not present in the model, so it does not play a structural role in the transmission mechanism of monetary policy. New Keynesian models enriched with money demand function are able to reflect the long-term relationship between money

¹ Other microeconomic justification for including money in macroeconomic models is provided by *cash-in-advance* models (CIA, Clower 1967) in which the importance of money results from the technology of concluding transactions, i.e. from the fact that some transactions, concerning *cash goods*, cannot be concluded without money (as opposed to transactions involving *credit goods*). However, attempts of empirical verification of CIA models do not provide encouraging results, by significantly underestimating the volatility of velocity of the circulation of money or by leading to other results that are inconsistent with empirical observations (cf. e.g. Hodrick et al. 1991, Christiano and Eichenbaum 1992).

 $^{^{\}rm 2}$ In the case of an open economy, in addition to these equations, the exchange rate equation is also used.

and prices suggested by monetarists³, however this relationship is not causal. The direction of causality between money and inflation seems to be difficult to determine due to the endogenous nature of both variables (e.g. Svensson 2003). Thus, money can be at best used as an information variable – obviously provided that it contains information on the state of the economy that is useful for the central bank.

Relaxing the assumptions of the standard new Keynesian model, one can find premises for inclusion of money in the analysis of selected channels of the monetary policy transmission. If there exist financial market imperfections and the associated non-homogeneity of financial assets (differing in the degree of liquidity and risk), money may be important in modelling the bank lending channel.⁴ In the canonical model of the bank lending channel, Bernanke and Blinder (1988) derive a so-called CC curve (*Commodities and Credit*) – the equivalent of the IS curve taking into account the non-homogeneity of assets of commercial banks. The CC curve is, similarly to the IS curve, negatively sloped, nonetheless it is additionally shifted under the influence of monetary policy and credit market problems. The variable reflecting the impact of monetary policy on the loan supply in the original Bernanke and Blinder model (1988) are bank reserves.⁵ Attention to liquidity effects in the monetary policy transmission mechanism is also drawn by Christiano and Eichenbaum (1992) and Aksoy et al. (2009).

³ These models are also consistent with the principle of neutrality of money (cf. Woodford, 2007).

⁴ According to the theory of the bank lending channel, loans and other revenue generating instruments are not perfect substitutes (due to differences in the level of liquidity and risk), which makes monetary policy impulses affect the structure of banks' balance sheets, including the supply of credit. These effects enhance the traditional interest rate channel.

⁵ Bank reserves consist of required reserves, proportional to the value of deposits (μ D), where μ is the reserve requirement rate and D is the amount of deposits, plus excess reserve. Banks can create credit to the value of deposits after paying the required reserves, that is D(1- μ). The increase of market interest rate leads to the decrease of banks' demand for deposits (because of the increase of cost). As a result, banks have smaller possibilities to create credit, if they cannot finance it using instruments which are not subject to reserve requirements, such as certificates of deposit.

Different studies relax assumptions of perfect competition in the money market, financial market, and credit market, e.g. Dai (2010). This allows to overcome the described before simplifications and to introduce loan interest rates used by commercial banks, medium-term lending rate in the money market and money into DSGE models. The derived optimum interest rates take into account indirectly (through the LM curve) information on the monetary aggregates. The work shows that if monetary and financial markets imperfectly transmit impulses from the monetary policy to the economy, then, in order to guarantee the optimality of the monetary policy, the interest rate should be revised by the information on the behaviour of monetary aggregates because the credibility of the central bank itself is not sufficient to anchor inflation expectations.

Nelson (2003) points to a different meaning of money as information containing variable. In his opinion and in accordance with monetarists' view, aggregate demand and money demand do not depend on the same interest rate, but on a number of different interest rates. Money measures the substitution effects, serving as a proxy for interest rates of instruments with different maturities. Money has the information value – it carries information regarding the level of aggregate demand for a particular short-term interest rate. In situations of incomplete information on aggregate demand, the implementation of optimum monetary policy requires the central bank's reaction function to contain the growth of money supply.⁶

Thus, economic theory does not provide a definite answer as to the importance of money in monetary policy analyses. There is no consensus as to whether the

⁶ There are many similar works (theoretical and empirical) indicating the importance of money as an argument of the central bank reaction function in a world of incomplete information. For example, in the work of Berg et al. (2010), money helps infer on data regarding the state of the economy which are available with a delay, especially on unobservable variables. The standard central bank's reaction function is supplemented with a monetary adjustment. The importance of money as an information variable seems to be relatively more important in economies with low levels of development where the data on real economy are generally of poor quality and available with a long delay. A similar concept of extending the standard central bank reaction function with a monetary cross-check is presented by Beck and Wieland (2010). We refer to these works in the empirical part of this paper.

nature of money is structural or – at best – money performs the function of the information variable, although a majority of studies supports the latter opinion. The financial crisis which began in 2007 proves, however, that the credit channels of monetary transmission exist and can play a more important role than this which emerges from the studies before 2007.⁷ On the other hand, owing to the rapid development of financial instruments money can include information significant for monetary policy not only when the real economy data is of bad quality or is available with delay, but in general (information which have importance for aggregate demand, but are difficult to observe in a different way than using data on monetary aggregates).

Experiences related to the monetary policy strategy based on monetary targeting are ambiguous. With the exception of the German Bundesbank and the Swiss National Bank in European countries and the U.S. the strategy was not particularly successful. Deutsche Bundesbank is an example of a consistent application of monetary targeting and the success achieved in its implementation was reflected in the development of the two-pillar approach to monetary policy of the European Central Bank. The ECB's monetary pillar signals inflationary pressures in medium and long term, whereas the second one, usually called economic pillar, which concerns analysis of demand and supply in the labour as well as goods and services markets– in the short term. Credit aggregates are used to analyse the risk of speculative bubbles in asset markets.

The central banks of the United States and the United Kingdom, in turn, used monetary aggregates as an intermediate target only temporarily, shifting towards multi-parameter strategies (so-called "just do it" strategy in the case of the Fed and inflation targeting strategy in the case of the Bank of England). The strategy was also implemented by the NBP in 1991-1997, thus, for a period of disinflation and rapid structural changes (privatization, increasing elasticity of markets, development of banking sector and capital market). Kokoszczyński

⁷ Compare with for instance Angeloni et al. (2003).

(2004) shows a relatively small effectiveness of monetary targeting in Poland. Nonetheless, during the period of a fixed exchange rate regime and administrative restrictions, i.e. between 1991 and 1993, the impact of monetary aggregates on inflation was stronger and the supply of money was easier to predict than in 1994-1997, when the attempts to simultaneously affect the exchange rate and money supply caused a decrease in the effectiveness of money supply control and a lower reliability of money supply forecasts, which diminished the usefulness of monetary aggregates in reducing inflation.

Central banks pursuing monetary targeting strategy faced many problems which in many cases challenged the rationale of its application. It is worth noting that the optimal monetary policy, which minimizes GDP fluctuations, should use monetary aggregates in the stable money-demand environment (when the IS curve shocks and not the LM curve shocks prevail in the economy) and when money demand is strongly affected by the interest rate (flat LM curve). However, when the real shocks dominate in the economy, then the minimal GDP fluctuations are assured by using the interest rate and not monetary aggregates. Thus, the relation between nominal and real shocks as well as structural characteristics of an economy determine the choice between money and the interest rate (Poole 1970).

Though, money-demand function turned out to be unstable or seemed to be unstable. The rapid development of financial instruments and liberalisation of financial markets caused that the correct assessment of money demand function required taking into account a wider than previously range of financial and nonfinancial assets' profitability. The velocity of money circulation became difficult to estimate due to increased volatility. This complicated the assessment of the impact of money supply on key macroeconomic variables (nominal income and inflation). Central banks repeatedly changed the monetary aggregates controlled and the manner of calculating them. In the case of the central banks of the United States and the UK, some common characteristics may be distinguished which have contributed to the failure of monetary targeting. On the one hand, the relationship between money and key macroeconomic variables became very difficult to predict. On the other hand, the monetary authorities of these countries showed relatively little concern for communication with the public and little attachment to the policy pursued. Their actions were in fact unclear, marked by irregular announcements of targets, setting targets for a number of aggregates, frequent exceeding of set ranges of fluctuations, lack of clarification of the target range and factors which pushed monetary aggregates outside the target range. It seems that the use of monetary targeting served only as a method to influence the expectations of the public. Germany and Switzerland owe the successes in the implementation of monetary targeting to the particular features of their policies. These factors include: effective communication, a high degree of flexibility of the strategy used and a relatively stable money-demand function. In Poland the structural changes and, mentioned before, necessity to accumulate foreign exchange reserves have undoubtedly influenced instability of money demand function and difficulties in using monetary targeting strategy.

2. Money in monetary policy – a review of empirical research

2.1. Money-inflation relationship

Empirical studies on the relationship between money and inflation usually apply theoretical models inspired directly by the quantity theory of money (e.g. de Grauwe and Polan 2005) or models being a compilation of various theoretical schools, usually the quantity theory and the new Keynesian model. Two main approaches may be distinguished in the latter case. The first one proposes to introduce money directly to the central bank reaction function, as an additional information variable (rejection of the assumption of full information, e.g. Beck and Wieland, 2010) or to supplement the new Keynesian model with the money-demand function. The second approach focuses on using money in explaining low-frequency components of price changes, leaving the standard new Keynesian model for components with higher frequencies (e.g. Gerlach and Svensson 2003).

2.1.1. Studies on money-inflation relationship using the quantity theory of money

The study of de Grauwe and Polan (2005) conducted for 160 economies and covering 30 years (1969-1999) is a good example of studies testing the quantity theory in large groups of countries.⁸ The authors show that in the case of countries with low inflation (below 10%) it is difficult to find any relationship between inflation and M1 and M2 monetary aggregates – the correlation between these variables is not significantly different from zero. Adding to the sample countries with inflation between 10% and 20% increases the correlation between the M1 monetary aggregate and inflation to 0.7, while for the full sample of economies this correlation is nearly 0.9. It is worth noticing that in

⁸ For instance, McCandless and Weber (1995) – 110 countries, Dwyer and Afer (1999) – 79 countries.

countries with low inflation, higher money growth does not lead to a proportional increase in inflation in the long term and it does not affect GDP growth. This suggests the existence of a negative correlation between the increase in the quantity of money and changes in the velocity of its circulation. It seems that the negative correlation may be an artefact, resulting either from technological and institutional changes in payment systems or from the averaging of the results from many countries experiencing different inflationary regimes. In countries with high inflation an increase in the quantity of money has more than a proportional effect on inflation and a negligible impact on GDP growth. This suggests a positive correlation between changes in the quantity of money and changes in the velocity of money, which is characteristic of episodes of hyperinflation (increase in the quantity of money leads to an increased velocity of money in circulation, which speeds up inflation).

Orphanides and Porter (2001) test the quantity theory of money on data from the United States. Analysis for 1961-1988 shows that there is a significant correspondence between price changes and changes in the quantity of money at a constant (1.65) velocity of circulation– *ex post* and *ex ante* inflation forecasts determined on this basis do not differ significantly from the actual price growth, despite the introduction by banks of new financial instruments. In the nineties of the twentieth century, due to changes in the velocity of money (1.9-2.0), forecasts of inflation determined under the assumption of a constant velocity of money no longer reflected the actual inflation performance. Therefore an attempt was made to make the velocity of money time varying by making it dependent on the opportunity cost of money, defined as a deviation of the price of 3-month government bonds from the average price of money. Endogenising money velocity, and in particular taking into account the opportunity cost of holding money, significantly improved the quality of forecasts in the nineties.⁹

⁹ Conclusions of other works of this type are consistent with the results of the work of Orphanides and Porter (2001), indicating the fluctuations of the velocity of money as a factor limiting the possibility of inferring on future inflation on the basis of monetary aggregates.

2.1.2. Studies on money-inflation relationship within the new Keynesian framework

Empirical studies on the importance of money for inflation processes are also conducted under the new Keynesian economics, where attempts are made to enhance its models – in accordance with theoretical premises indicated earlier – with the information contained in monetary or credit aggregates.

The first stream of empirical studies of this type emphasises the importance of money as an additional information variable which is important in the case of incomplete (or available with a delay) information.

Berg et al. (2010) expand the standard new Keynesian model with the money demand equation and a monetary adjustment in the central bank's reaction function¹⁰. Estimated weight of the monetary adjustment in the reaction function of monetary authorities reflects the usefulness of the information contained in monetary aggregates for inferring about data on the state of the economy - available with a delay, but necessary for forecasting inflation (in particular on unobservable variables such as output gap, natural interest rate or expected inflation). The study was conducted for three African countries with a relatively low inflation: Ghana, which has been implementing inflation targeting since 2004, Uganda and Tanzania, officially implementing monetary targeting. In addition to the estimation of the weight of the monetary adjustment on the basis of actual data, its optimum values were determined. In Uganda and Tanzania, the optimum weight of the monetary adjustment is similar to the weight estimated on the basis of actual data. This means that the central banks of both countries derive information from the money market in an almost optimum manner, with Tanzania gaining relatively more from the implementation of

¹⁰ The equation is as follows: $R_t=R_{t|t-1}T+[(1-\lambda)/\lambda](\Delta M_t-\Delta M_{t|t-1}T)$, where R is the interest rate, while R^T and M^T are targets of the central bank which are consistent with each other and concern the interest rate and money supply. This equation can provide an answer to two questions: how the short-term interest rate should be changed depending on the development of monetary aggregates, or whether the central bank may change the amount of money (liquidity) in relation to the planned amount if interest rates are different than desired.

monetary targeting. In turn, in Ghana, where the optimum weight of the monetary component is much higher than estimated, the results of inflation targeting could have been better if the central bank had paid more attention to monetary aggregates.¹¹

Beck and Wieland (2010) also relax the assumption of completeness of the information available to market participants and the central bank. Although in their concept money does not play a structural role (it is present neither in the IS curve nor in the Phillips curve), it can be used to reduce the effects of measurement errors of unobservable variables.¹² On the basis of simulations carried out with the new Keynesian model, taking into account the distribution of revisions of the output gap estimates for Germany and the U.S., Beck and Wieland (2010) proposed the introduction of so-called *monetary cross-check* to the central bank reaction function. In this concept, the interest rate is determined by the sum of the optimum interest rate derived from the standard new Keynesian model, and the monetary cross-check, minimising effects of the deviation of potential output from its real value. The idea of monetary cross-checking maintains the distinctiveness of economic analysis using the new Keynesian model and monetary analysis, using a simple model that includes a long-term relationship between money and inflation.¹³ The monetary component is "activated" when money growth rate deviates from the growth rate typical for a stable inflation. For the model calibrated by the authors, the critical value of this deviation is approximately 6 percentage points and the corrective reaction of the central bank should take place if deviation persists more than 4 quarters.

¹¹ Paying too much attention to monetary aggregates would result in an increased stability of inflation, but also in a significant decrease in the stability of the output gap.

¹² In the New Keynesian model the optimum interest rate depends on variables that are not directly observable (such as potential output) and characterized by relatively big measurement errors (cf. e.g. Orphanides 2003). The central bank estimates unobservable variables in accordance with its best knowledge at the time. Based on these estimates, monetary policy is implemented. Then, the estimate of, for instance, potential output is corrected from a historical perspective, due to which previously estimated gaps deviate from their true level by a certain value.

¹³ In this sense it is an idea consistent with the two-pillar monetary policy of the European Central Bank.

Kajanoja (2003) examines the importance of money in the case of incomplete information. Simulations on the model for the euro area, in which the demand for money is to some extent forward-looking¹⁴, show that negative effects of incomplete information – resulting in inadequate decisions in the monetary policy – can be significantly reduced through the use of money as an information variable. However, this conclusion is true if disturbances to the money-demand function are relatively small, the demand for money is forward-looking, and market participants have information advantage over the monetary authorities. Relaxing these assumptions significantly reduces the information value of monetary aggregates.

The second area of empirical works on the role of money conducted in the new Keynesian school is associated with the concept of the two-pillar Phillips curve. While maintaining determinants of inflation that are characteristic for the new Keynesian economics, studies of this kind enhance them with monetary variables.

When examining the relationship between inflation and money for the euro area countries, Gerlach and Svensson (2003) noted that the difference between M3 growth and its reference growth rate in the Eurosystem has little predictive power, while the real money gap (i.e. the difference between the real money stock and the long-run equilibrium real money stock) has significantly better predictive properties than the output gap. Explanatory variables of inflation in the two-pillar Phillips curve are as follows: expected inflation, output gap and money gap. In addition, energy prices which explain mostly short-term variations in inflation (4-6 quarters) are also considered. The results of the estimation (Table 1) show that both the money gap and the output gap contribute significantly to explaining changes in prices in the euro area – both before the introduction of euro (1981-1998) and in the full sample (1981-2001). Other variation in the full sample (1981-2001).

¹⁴ In this specification money depends on its delayed value, money from the next period, economic activity and interest rate. The calibrated value of the parameter determining the degree of the predictability of demand for money for the euro area is 0.37.

ables are significant at 1% and parameter values do not change significantly in variants of the estimation taken into account. It is worth noting that in the period before the introduction of the euro the information value of the real money gap was significantly higher than in the case of the output gap and declined after the introduction of the euro . This may be associated with the method of aggregating data for the pre-euro period adopted by the authors, the specification of the equation of demand for real money, used for calculating the money gap¹⁵ or the method of estimation of the equation¹⁶. It seems the least probable that the increase of demand elasticity was caused by the euro adoption¹⁷.

Table 1. Selected results of the estimation of price equation - Gerlach and Svensson(2003)

	Sample: 1981q2 -1998q4			1981q2-2001q1
	Estimation without output gap	Estimation without money gap	Estimation with both gaps	Estimation with both gaps
parameter for the money gap	0.280	-	0.241	0.192
parameter for the output gap	-	0.194	0.155	0.177

A slightly different approach to the determination of the role of money in modelling inflation is presented in the work of Assenmacher-Wesche and Gerlach (2006). The authors believe that the quantity theory of money and the new Keynesian model may be brought together by separating the determinants of inflation in a very short (up to 1.5 years), short (up to 7 years) and long (over 7 years) period. Using frequency filters, they extract series containing frequen-

¹⁵ In order to operationalise the concept of the real money gap, it is necessary to calculate the demand for real money depending on the velocity of money. The income elasticity of money demand calculated in that equation, ensuring long-run equilibrium is 0.98, it is constant over the analysed period and close to one, i.e. a theoretical value, predicted by the quantity theory of money. The trend, i.e. the constant change of the velocity of money, is an equally important variable: for euro area countries it is an increase of 1.25% per annum. The opportunity cost of money (the difference between long-term interest rates and the market price of money) is equally important – a change of the opportunity cost by one unit causes a change in money stock by 0.85.

¹⁶ De Bondt (2009), Nautz, Rondorf (2010) pay attention to the relationship between the results and the selection of variables, the applied method of data aggregation and the method of estimation.

¹⁷ For instance Beyer (2009) estimates the income elasticity of demand in 1990 as 1,6, and in 2005 as 1,7.

cies corresponding to mentioned above periods from time series of inflation in the euro area countries in the period of 1970-2003. Then they propose the model of inflation where the low-frequency inflation component depends on the rate of growth of M3, GDP and a long-term interest rate, the average frequency inflation is influenced by the output gap, while the highest-frequency inflation component is explained by cost disturbances (the price of oil, change of the exchange rate, import prices). The estimation results show that there is a long-term relationship between inflation and the rate of money growth (the coefficient is 0.89 and not significantly different from one)¹⁸, other variables are also important. On the other hand, the results seem to depend on the choice of the filter. In addition coefficients estimated for a particular frequency differ for the one equation model and for the new Keynesian model, suggesting incorrect specification of the first equation rather than structural relationships.¹⁹

2.2. Using money to approximate other macroeconomic variables

Another area of the use of monetary or credit aggregates is to approximate other macroeconomic variables, such as real variables, or prices of financial assets.

2.2.1. Approximating real variables

Many empirical studies exploit monetary aggregates to approximate data from the real economy, usually available with a delay. For instance, Hafer et al. (2007) estimate the aggregate demand curve for the U.S. economy for 1960-2000, by including monetary aggregates (M0, M1, M2) in the set of explanatory variables. The resulting estimates are more stable than the IS curve estimated in its standard form.

¹⁸ Benati (2005) found a similar relationship by examining series for the U.S. and Great Britain from the period of 1870-2003 – a coincidence in time and magnitude of deviations from the inflation trend and the rate of money growth is surprisingly high.

¹⁹ It seems that this current of studies is to support the two pillars of the ECB monetary policy rather than to improve the properties of inflation forecasting models.

Using the model for the euro area economy, Coenen et al. (2005) show that money can be an information variable facilitating estimations of the current level of output, however the benefits in this respect are considerable if the uncertainty of current output measurement is high, distortions of money demand function are insignificant and the central bank attaches great importance to reducing cyclical fluctuations in the real economy. From this perspective information content of monetary aggregates for approximating aggregate demand in the euro area seems to be small.

2.2.2. Money and asset prices

During the financial crisis, regardless of their monetary policy strategy, central banks in the most affected countries resorted to unconventional quantitative measures in addition to the traditional tools of monetary policy (interest rates). An interesting case is the policy of quantitative easing started by the Bank of England in March 2009 by expanding money supply through large-scale purchases of public and private sector assets. When analysing its transmission to the economy, attention is drawn to two main channels of the impact of increased money supply on the aggregate demand and inflation (Benford et al. 2009). The first channel concerns the impact – both direct and through the expectations of market participants - on asset prices, and through wealth effects and a decrease in the costs of borrowing caused by this - on the aggregate demand and price developments. The second channel regards the impact of increased liquidity on the supply of credit (Figure 1). These are traditional channels of monetary policy transmission (cf. e.g. Mishkin 2001), and to analyse and model them - also in the case of a traditional policy of controlling the shortterm interest rate by the central bank – monetary aggregates are often used.²⁰

²⁰ At this point, it is worth recalling a thesis previously formulated by Goodhart (2007) that the standard new Keynesian model – such as the Woodford model (2003), i.e. built around the IS curve, Phillips curve and monetary policy rule – is appropriate in periods of relative stability, while in periods of disturbance, especially deflationary disturbances, when expectations are no





There are a number of studies that verify the usefulness of monetary aggregates in the analysis of financial asset prices and assessing imbalances (i.e. bubbles) in the asset markets. In general, these studies show that the relationship between monetary aggregates and asset prices is fairly weak, and the possibility to identify imbalances in the asset markets – limited.

Based on the sample of observations from 16 industrialised countries covering the period from the early eighties, Ferguson (2005) shows a lack of a statistically significant correlation between the rate of growth of broad money M3 and changes in financial asset prices (correlation coefficient: -0.08). According to Ferguson (2005), such a result may be caused by a high volatility of asset prices. The correlation of money growth with real estate prices turns out to be positive but relatively small (0.28).

Based on observations from the United States covering the period from 1830, Bordo and Wheelock (2004) suggest²¹ that it is difficult to demonstrate that periods of boom in financial asset markets were preceded by excessive expansion of monetary or credit aggregates (the nineteenth century is an exception in

longer anchored and interest rates reach a level close to zero, monetary aggregates may be a better measure of monetary policy than interest rates.

²¹ It should be noted that the analysis performed is of a narrative nature.

this respect, where periods of boom in the asset market are accompanied by monetary expansion). Growing imbalances in the asset markets may be however associated with periods of strong growth in real GDP and productivity, also accompanied by accommodative growth of monetary aggregates.

Adalid and Detken (2007), having analysed periods of booms in the asset market in 18 OECD countries from the early seventies, show that monetary aggregates (after elimination of cyclical fluctuations) allow to infer about bubbles in asset markets and the depth of the recession following the collapse of asset prices.²² The authors point out that taking into account the entire sample – and not only periods of booms – the relationship between liquidity shocks and changes in asset prices is much weaker.

It should be noted that much of the empirical work in this area provides relatively better results if in analysing asset prices credit aggregates are used instead of monetary aggregates. For instance, based on a sample of 17 OECD countries in the period of 1969-2008, Gerdesmeier et al. (2009) show that credit aggregates (and not monetary aggregates) and long-term changes in interest rates and in the ratio of investments to GDP constitute the best indicators allowing to predict bubbles in the asset markets even 8 quarters in advance. Similarly, Machado and Sousa (2006) point to the predominance of credit over monetary aggregates in explaining excessively high or low prices in asset markets in the euro area.

²² The work of Alessi and Detken (2009), which tests the warning indicators of booms in the market of (financial and real) asset prices, relates to a similar group of countries and a similar period. The authors conclude that the best warning indicators are monetary variables of a global nature, i.e. the global M1 monetary aggregate gap and the global credit gap.

3. Role of monetary aggregates in the Polish monetary policy

Given the theoretical foundations described in the previous chapters and the results of empirical studies on the relationship between money and inflation it seems that it is not adequate to resign from analysis of monetary aggregates as information variable useful for conducting monetary policy. However, the quality of this information should be sufficiently good and the weight given to this information – not too high.

3.1. The analysis of stability of money demand function

During the period of inflation targeting strategy in Poland the quality of information delivered by monetary aggregates is associated directly with the stability of the long-term money demand function. The function was estimated for the period from the first quarter of 1998 to the second quarter of 2011 using the method of variable cointegration of Johansen and Juselius (1990). We tested M2 and M3 aggregates. The obtained results are very similar to each other, thus, we present only these for the wider aggregate.

We use the standard specification (cf. e.g. Juselius, 2006), however, as we model a small open economy we take into account the exchange rate in real terms. Our sample covers the years of a fast growing stock exchange capitalisation, therefore it seemed important to us to take into account the effects of this phenomenon. We use the following model:

$$(1) m_t - p_t = \alpha_0 + +\alpha_1 y_t + \alpha_2 i_t^{TB} + \alpha_3 i_t^m + \alpha_4 wealth_t + \alpha_5 er_t,$$

where: m_t is M2 or M3 money in nominal terms, p_t is the price level (GDP deflator), y_t is GDP, i_t^m – deposit interest rate, approximating the return from holding assets in the form of cash, i_t^{TB} is the yield of one-year Treasury bills, approximating the cost of holding assets in cash. The difference between the yield of

Treasury bills and deposit interest rate is a measure of the cost of lost benefits from holding assets in cash. Variable *wealth*_t is the equity price index (WIG) in real terms (CPI is used as a deflator), whereas er_t is the real effective exchange rate (the increase means appreciation)²³. All variables, except interest rates²⁴, are in the form of logarithms. We expect that $\alpha_2 < 0$, α_1 , $\alpha_3 > 0$, and that $\alpha_2 = -\alpha_3$. The issue of α_4 and α_5 sign is open. On the one hand, the increase of the equity price index can cause the increase of money demand, due to the wealth effect predicted by Friedman (1988) and/or the financial transactions channel (an increase in equity prices may imply an increase in transactions and, thus, the demand for money). A positive sign of α_4 may also result from the effect of the so-called excessive credit channel – excess revenue from equities is often accompanied by strong growth in credit and money, cf. Gerdesmeier et al. (2009). In turn, the effect of substitution of assets – money and securities may cause α_4 to be negative. A detailed discussion on the relationship between money and equities may be found in de Bondt (2009). The appreciation of domestic currency can also cause the substitution effect, namely the substitution of foreign currency with domestic currency. In such a case α_5 will be positive. If, on the other hand, the negative effects of domestic currency appreciation on economic situation prevail, it will be negative.

We test the unit income elasticity of money demand ($\alpha_1 = 1$) predicted by the quantity theory and the possibility of bringing both interest rates to a spread, i.e. ($\alpha_3 = -\alpha_4$).

A preliminary assessment of the degree of integration of time series used was performed with the use of the ADF test; the hypothesis that the variables are second-order integrated was rejected, however it was not rejected that they are

²³ A dummy variable was introduced which reflects changes in the economy after the Polish accession to the EU (zero until the first quarter of 2004 and one for the rest of the sample) and in order to obtain a normal distribution of residuals – a dummy variable for the acute phase of the financial crisis (fourth quarter of 2008).

²⁴ Interest rates are expressed as fractions, i.e. for instance 5%=0.05.

first-order integrated. In the first step the parameters of the model in which the money was in nominal terms were estimated. This enabled to test the unit homogeneity of money and prices – in real terms the assumption is implicitly assumed to be satisfied.

For the data where money is in real terms the Johansen test with Bartlett correction for a small sample²⁵ rejects the hypothesis of no cointegration and one cointegrating vector. Therefore, we assume the existence of two cointegrating vectors, one of which is a money demand function and the other approximates the equation of deposits' interest rates in the banking sector. We find neither skewness nor statistically significant autocorrelation of residuals. Stationarity test confirms that under the assumption of two cointegrating vectors all variables in the model are first-order integrated.

The analysis of cointegrating vectors and the matrix of loading coefficients show²⁶ that in the case of disequilibrium between money demand and money supply, adjustments in deposit interest rate and real exchange rate occur and restore equilibrium. During the first quarter after the disturbance about 37% of the disequilibrium is eliminated. The only weakly exogenous variable is the return on equity. The tables with detailed results are in the Appendix. Point estimate of the elasticity of money demand relative to the scale variable is greater than one. It is not possible, however, to reject the hypothesis that the coefficient is equal to one ($\alpha_1 = 1$) and the hypothesis of spread ($\alpha_2 = -\alpha_3$). Following the adoption of these restrictions and the restriction which eliminates money from the second equation we obtain overidentified two long-run rela-

²⁵ The number of delays was determined with the use of the information criterion also distribution of residuals was taken into account. As a result, the model was estimated with one delay. Estimates were performed in the CATS in RATS package.

 $^{^{26}}Based$ on the analysis of statistically significant coefficients Alpha and their comparison with corresponding elements of Beta vector, disequilibrium elimination mechanisms can be inferred. If a statistically significant coefficient α_{ij} has a corresponding element β_{ij} with the opposite sign, then there exists a process of return to equilibrium after the disturbance.

tions²⁷. The second relation can be interpreted as the exchange rate equation or the deposits' interest rate equation²⁸. Below we present money demand equation with restrictions (absolute values of t-statistic in parenthesis):

(2) $(m3_t - p_t) = y_t - 5.7(i_t^{TB} - i_t^m) + 0.08wealth_t + 0.58er_t.$ (-) (19.24) (10.13) (2.79)

The 1% increase of GDP causes the 1% increase of money demand. The 1% increase of spread causes, on the other hand, about 5-6% decrease of money demand. The appreciation of zloty causes the effect of substitution between foreign and domestic currency. The 1% increase of equity prices in real terms causes 0,1% increase of money demand, what means that there appears a small wealth effect.

Since our main goal is to answer the question whether monetary aggregates could contain additional information that should have been used in monetary policy, the resulting long-run relations were examined from the perspective of their stability. The tests covered both the cointegration vector and the coefficient of adjustment to equilibrium. The idea of the test is to estimate the model

²⁷ Test χ^2 (1) = 0.339 [0.560], thus it is not possible to reject the restriction.

²⁸ The way of interpreting is often to certain extend a result of researcher's decision, especially when the data set gives more than one possibility. It is also our case. Interpretation of the second equation is a bit beside the main topic of our study, therefore, we present it briefly. Thus, it can be interpreted in two ways: either as an equation of the exchange rate or of the deposits' interest rates in commercial banks. If the long-term relationship is interpreted as the exchange rate equation, we obtain the following results: the exchange rate depends positively (appreciation) on the profitability of T-bills and macroeconomic fundamentals, approximated by GDP. The increase in yields of Treasury securities and good performance of the economy stimulate the inflow of capital. Depreciation, in turn, causes the increase of bank deposit interest rates (currency substitution) and the increase of the profitability of equities (substitution of foreign currency assets and equity). If, however, we interpret our relationship as a long-term deposit interest rate equation, the results show that it grows in line with T-bills profitability (an alternative to deposits) and GDP (probably due to the growing demand for loans). Interest rates decrease along with the appreciation of the Polish zloty - increase in demand for domestic money allows banks to lower interest rates. It also falls when equity profitability increase. The latter effect can mean that stock market investments are not an alternative to deposits. In both cases, the long term adjustment coefficient is not statistically significant, what indicates that in the equation the return to equilibrium could be incomplete. Note, however, that the t-statistic is not a good criterion which allows to conclude on stationarity of obtained relations, in part because of possible collinearity of cointegrating relationships, and partly because it is not known whether to interpret it as the Student's t-statistics, or as the Dickey-Fuller τ (Juselius, 2006).

on a sub-sample, and then to recursively test whether further observations do not alter the previously estimated parameters. We tested both if the parameters are stable when the base subsample consist of observations from 1998Q3 to 2007Q3 and the subsequent observations are added forward to 2011 and when the base subsample consist of observations from 2002Q1 to 2011Q1 and the subsequent observations are added backward to 1998.

In the case of the "forward" test we added the observations from the financial crisis. The stability tests show that (see Appendix, Figures A1-A5) although in 2008-2009 some disturbances are visible, it is not possible to state that the parameters of money demand function are instable. It might be clearly seen that the interest rate coefficients from the cointegrating relation (the return on Treasury bills and deposits' interest rates in commercial banks) were slightly less stable than the respective parameters of return on equity and real exchange rate (Figure A3).

In the case of the "backward" test we added the observations from the beginning of inflation strategy in Poland (see Appendix, Figures A6-A10). As it was mentioned before, one of the reasons for implementing the strategy was conviction about money demand instability. In contrary to the "forward" test the second test indicates that the period 1998-2001 was different from 2002-2011, what is confirmed by then-analysis of the money demand (Figure A10). The results suggest that money can contain information which is important for monetary policy. It is, however, not the case of whole analyzed sample. Therefore, if money was the variable taken into account by the central bank, its weight in the reaction function and informative value should change in time. High semi-elasticity of money demand on interest rate can also be the reason for using monetary aggregates in monetary policy.

3.2. The estimation of the weight of monetary aggregates in the central bank reaction function

The analysis of money demand function suggests that semi-elasticity of money demand in relation to the cost of lost benefits adopted by us is relatively high, which should rather encourage a more active use of monetary aggregates in the central bank reaction function. Demand for money has been stable, at least since 2007. This would mean that since 2007 additional information could be obtained on the basis of the behaviour of monetary aggregates.

The estimation of relative weight of both types of information over the analysed period and comparing it with the optimal one, can be the premise for assessing monetary policy effectiveness.

The study by Berg et al. (2010), described in chapter 2.1, relates directly to the issues raised above. The authors proposed the method to expand the standard new Keynesian model to show the role and the weight of information contained in monetary aggregates for the monetary policy. The results obtained by them show that monetary aggregates should play a greater role if the demand for money is stable, interest rate semi-elasticity of money demand is relatively high (flat LM curve), there are many disturbances in the money market interest rates or if the economy experiences strong real shocks. These conditions are consistent with postulates of Poole (1970) discussed earlier.

In the next step, using model solutions, Berg et al. (2010) defined a function that allows to estimate the optimum weight of monetary aggregates. It is assumed that the central bank interest rate and the rate of money growth are communicated to the market by the central bank based on the information from the t-1 period, i.e. from the period for which all information is available and complete. On this basis, i.e. *ex post*, money demand function determines unambiguously the interest rate and money growth. In the t period the central

bank, observing the market interest rate and the increase in the quantity of money, must decide whether to adjust the price of money or the quantity of money to the previously declared values. This decision-making dilemma can be written in the following equation:

(3)
$$\lambda(R_t^N - R_{t|t-1}^{Tar}) - (1-\lambda)(\Delta M_t - \Delta M_{t|t-1}^{Tar}) = 0$$
,

where R_t^N is the nominal interest rate, $R_{t|t-1}^{Tar}$ the desired (target) nominal interest rate, ΔM_t is the increase in the quantity of money and $\Delta M_{t|t-1}^{Tar}$ – monetary target. λ is the weight assigned by the bank to the information derived from observations of the interest rate. If inflation targeting is implemented and the central bank also wants to use the information contained in monetary aggregates (for reasons discussed in Chapter 3), then the following correction can be introduced into the central bank reaction function, which takes into account the information from the monetary aggregates:

(4) $R_t^N = R_{t|t-1}^{Tar} + [(1-\lambda)/\lambda](\Delta M_t - \Delta M_{t|t-1}^{Tar}),$

where:

(5)
$$R_{t|t-1}^{Tar} = (r^* + \pi^{Tar}) + \varphi_{\pi}(\pi_{t+1} - \pi^{Tar}) + \varphi_y y^{GAP}$$
,

(6) $\Delta M_{t|t-1}^{Tar} = \Delta M_t^* - m_{t-1}^{GAP} + (\pi_t - \pi^{Tar}) - \delta(\pi_{t+1} - \pi^{Tar}) - \gamma y^{GAP}$,

(7) $m_t = \chi_y y_t - \chi_R R_t + u_t$.

The above equations use the following symbols:

r *- desired domestic real interest rate (corresponding to zero output gap),

 π^{Tar} – inflation target,

 π_{t+1} – expected inflation,

y^{GAP} – output gap,

mt – real money,

 $(\Delta M_t^* - m_{t-1}^{GAP} + (\pi_t - \pi^{Tar}))$ – correction introduced to the monetary target which allows to accommodate excess liquidity from previous period adjusted by current price mismatch,

yt – GDP, constant prices,

Rt – nominal interest rate,

ut – random variable determining changes in the velocity of money.

Equation (4) defines the short-term interest rate with a monetary adjustment. Equation (5) determines the level of the desired (target) short-term interest rate using the classic Taylor reaction function. Equation (6) describes how the desired rate of growth of the monetary aggregate is determined. It depends negatively on the liquidity gap in the previous period adjusted with current price mismatch, positively on the difference between expected inflation (model consistent) and the level of the inflation target, and negatively on the output gap. Equation (7) is a simple money demand function.

Solving the presented series of equations in relation to the nominal interest rate, we obtain the weight assigned to inflation (ϕ_{π}) and GDP (ϕ_{y}) in the monetary policy rule:

(8) $\varphi_{\pi} = \delta / \chi_{R}$ and $\varphi_{y} = (\gamma + \chi_{y}) / \chi_{R}$.

A key role in determining the information content of monetary aggregates is thus played by the interest rate semi-elasticity of money demand (χ_R). As mentioned earlier, a high semi-elasticity of money demand reduces the interest rate response to inflation, which makes it is necessary to introduce a relatively large correction to the planned money supply in response to the expected inflation. This in turn increases the role of information derived from the monetary aggregates in the Taylor rule (the closer λ is to zero, the bigger the correction resulting from the information derived from the money market).

The introduction of a monetary adjustment, i.e. the information derived from the observations of the quantity of money, may help the central bank to revise the forecasts of inflation, output gap and the equilibrium rate, which in turn will affect the decisions concerning the central bank interest rate, thus reducing the possibility of errors in communication with the market. The optimum size of the λ parameter minimises deviations of money growth from desired growth and the nominal interest rate from the desired rate:

(9)
$$(\Delta M_t - \Delta M_{t|t-1}^{Tar}) = \Phi(R_t^N - R_{t|t-1}^{Tar}), \lambda_{opt} = \Phi/(1 + \Phi).$$

The model developed for the purposes of the present study employs the concept of a monetary adjustment to the central bank reaction function and the introduction of the optimum weight of information derived from observations of the quantity of money proposed by Berg et al. (2010). A direct adaptation of the entire model was pointless because it referred to three African countries with low inflation but with an incomplete and delayed access to statistical data and the monetary transmission mechanism, which functions in a different way than in Poland. Therefore, when developing a model to be used for assessing the role of monetary aggregates in the Polish monetary policy, the structure and the method of the estimation was based on the Global Economy Model (GEM) from the study by Laxton and Pesenti (2003), Global Projection Model (GPM) from the study by Carabenciov et al. (2008) as well as on the experiences from the research on the monetary policy transmission mechanism in Poland (using, among other things, a small transmission model based on the new Keynesian tradition, MMT^{29}). The structure of the model incorporating the information adjustment is presented in Figure 2.

The model was estimated using methods available in the Dynare package, on quarterly data from the years of the application of the inflation targeting in Poland (first quarter 1998 - first quarter 2011). M1, M2 and M3 monetary aggregates were tested. The best results were obtained for M3. The proposed model retains satisfactory dynamic properties. Responses to exogenous shocks do not differ from the standard responses for this class of models, save that model solutions are stable only for a very narrow range of parameter values and assuming a normal distribution of all parameters. Table 2 presents estimates of se-

²⁹ Cf. Demchuk et al. (2012).

lected parameters affecting the assessment of the information weight of monetary aggregates in the central bank rule.



Figure 2. Small new Keynesian model incorporating monetary adjustment for Poland

	δ	XR	φπ	φy
First quarter of 1998 -	0.63	1.36	0.45	0.42
first quarter of 2011				

Table 2. Values of selected parameters of the new Keynesian model incorporating mone-tary adjustment.

According to our estimates, we can conclude that in the period when inflation targeting was applied, monetary authorities attached comparable importance to the stabilisation of inflation and GDP, although these weights changed over time.³⁰

Figure 3 presents an example of the reaction of M3, the nominal interest rate without and with the monetary adjustment, GDP, GDP growth, output gap, inflation and price level to exogenous disturbance of demand for money for the entire period of inflation targeting (corresponding to the parameters contained in Table 2). Exogenous disturbance of the demand for money is defined as the change in velocity of money. In the analysed example, this corresponds to a decrease in the velocity by 10% of the velocity of money³¹. Given the money demand function, which uniquely identifies the growth of money and nominal interest rate, this shock causes a gradual increase in money demand (quantity) by nearly 16%.

³⁰ It can be assumed that in the early years of inflation targeting and the disinflation process carried out at that time, the weight of the inflation stabilisation was significantly greater than the weight of GDP stabilisation. Cf. e.g. Sirchenko (2008), Table 9.

³¹ A decrease in the velocity of money by 10% is a very large decline, corresponding to a deep crisis of the financial market. In the presented text it serves as an illustration of the functioning of the model. The real impulse should be several times lower (approximately 0.6%), then, without taking into account the monetary adjustment in the NBP rule, the nominal interest rate would react with an increase of 2 basis points. Taking into account the information correction which is characteristic for the NBP reaction function, the nominal interest rate would increase by 5 basis points, at a minimum, within the margin of measurement error, decrease in inflation and GDP.

As noted earlier, in the case of disturbances in money demand, the central bank should react using the interest rate and should reduce the money supply response. Excluding the monetary adjustment in the NBP rule, the nominal interest rate would react by increasing by approximately 0.35 percentage points. Including the information correction, characteristic of the NBP reaction function, the nominal interest rate reacts with an increase of 1 percentage point, causing a temporary drop in GDP growth by 0.15 percentage points and a maximum decline in inflation after approximately five quarters by 0.25 percentage points. The described force of the reaction of each category is lower than in the already cited MMT model.

A question arises whether the correction made was optimum. To answer it we compare the weight of information derived from the observation of interest rate (coefficient λ), estimated in the model, with the optimum weight. The estimated parameter λ is 0.23, while the optimum parameter λ opt is equal to 0.16. This means that if the information derived from the monetary aggregates had been used to a greater extent, the total volatility of interest rate and money around desired values could have probably been reduced.



Figure 3. Reaction of M3, nominal interest rate, GDP and inflation to sustained decrease in the velocity of money by 10%.

Summary and conclusions

In the economic theory there is no consensus on both the role of money in shaping the inflation processes and the importance of money in the monetary policy mechanism. There are attempts to combine achievements of monetarism and the new Keynesian school. In particular, many studies indicate that in the case of incomplete information or information available with a delay, money can be used as an information variable the use of which may facilitate the implementation of monetary policy.

Experiences of selected central banks discussed in this paper related to the active use of money as an intermediate target of monetary policy suggest that monetary targets were useful during the period of reducing inflation as a nominal anchor and communication tool. Success in reducing inflation was however achieved owing to high flexibility of monetary policy, whose actual shape resembled more multi-parameter strategies than the declared monetary targeting.

Empirical studies give quite different results as to the usefulness of monetary aggregates in monetary policy. The thesis of a stable relationship between money and inflation, especially in countries with developed financial markets and low inflation, is rather difficult to confirm. Better empirical results are obtained by including monetary analysis in the new Keynesian models, particularly by using money as an information variable, however such studies are relatively new and there is no evidence for unequivocal decision on their potential application.

The results obtained from a small new Keynesian model with a monetary adjustment suggest that taking into consideration the information derived from the observations of the quantity of money the total volatility of interest rate and money around the desired values could be probably reduced, however only slightly. The analysis of long-run money demand function containing a richer set of explanatory variables confirms these results.

Appendix

	m3	у	i ^{TB}	i ^m	er	wealth
Beta(1)	0,464	-1,073	-1,823	1,000	-0,071	0,078
Beta(2)	1,000	-1,548	1,528	-2,391	-0,417	0.032

Table A1: Beta cointegrating vector without restrictions imposed for M2

Table A2: Alpha loading matrix (coefficients of adjustment to equilibrium) with no re-
strictions imposed on Beta cointegrating vector

	Alpha(1)	Alpha(2)
dm3	0,233 (2,308)	-0,462 (-5,861)
dy	0,152 (4,249)	-0,097 (-3,464)
di ^{TB}	0,239 (4,670)	0,109 (2,744)
di ^m	-0,014 (-0,042)	0,093 (3,875)
der	-0,515 (-2,075)	0,437 (2,254)
dwealth	0,225 (0,437)	0,584 (1,453)

Figure A1. Stability test of imposed restrictions (X – full model, R1 – long-run term, values > 1 indicate instability)







Alpha 2 (R1-model)





Figure A4. Stability test of cointegrating vector (values > 1 indicate instability)

Test of Beta Constancy





Figure A5. Stability test of entire two cointegrating relations (values > 1 indicate instability)







Figure A7. Backward stability test of long term coefficients, money demand equation

Alpha 2 (R1-model)





Beta 2 (R1-model)

Figure A9. Backward stability test of cointegrating vector (values > 1 indicate instability)

Test of Beta Constancy



Figure A10. Backward stability test of entire two cointegrating relations (values > 1 indicate instability)



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